SIEMENS

MOBILETT Plus/ -E/ -M

SP

Function Description

From Serial No. MOBILETT Plus; 2050
MOBILETT Plus E; 10 001
MOBILETT Plus M; 20 100

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- MOBILETT Plus
- MOBILETT Plus E
- MOBILETT Plus M

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• Maintenance Protocol	SPR8-215.832...
• Installation Instructions "Installation of remote exposure system"	SPR8-220.031.02...

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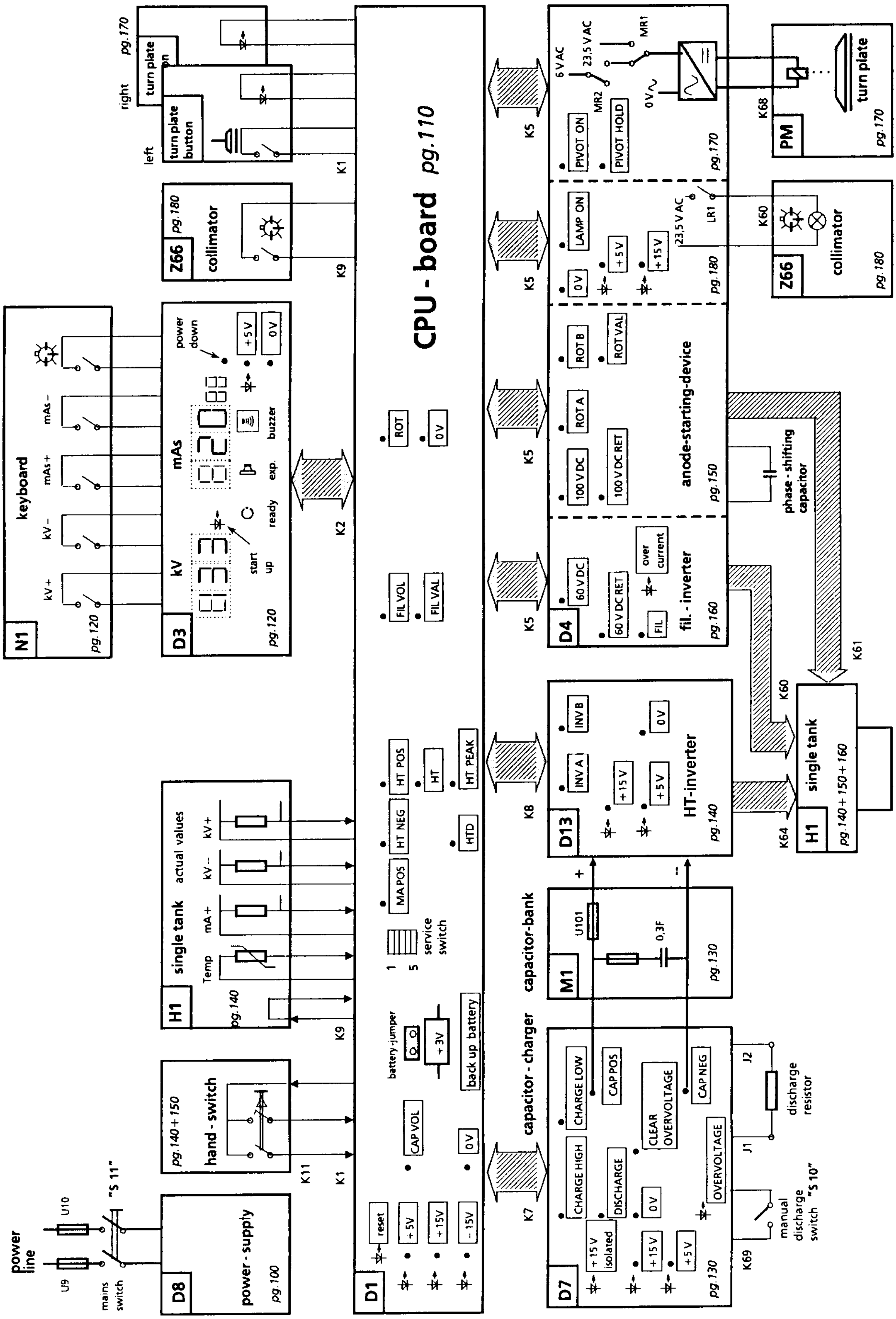

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MOBILETT Plus/ Plus E/ Plus M are mobile radiography units, with an output of up to 30 kW.

Parts and Controls

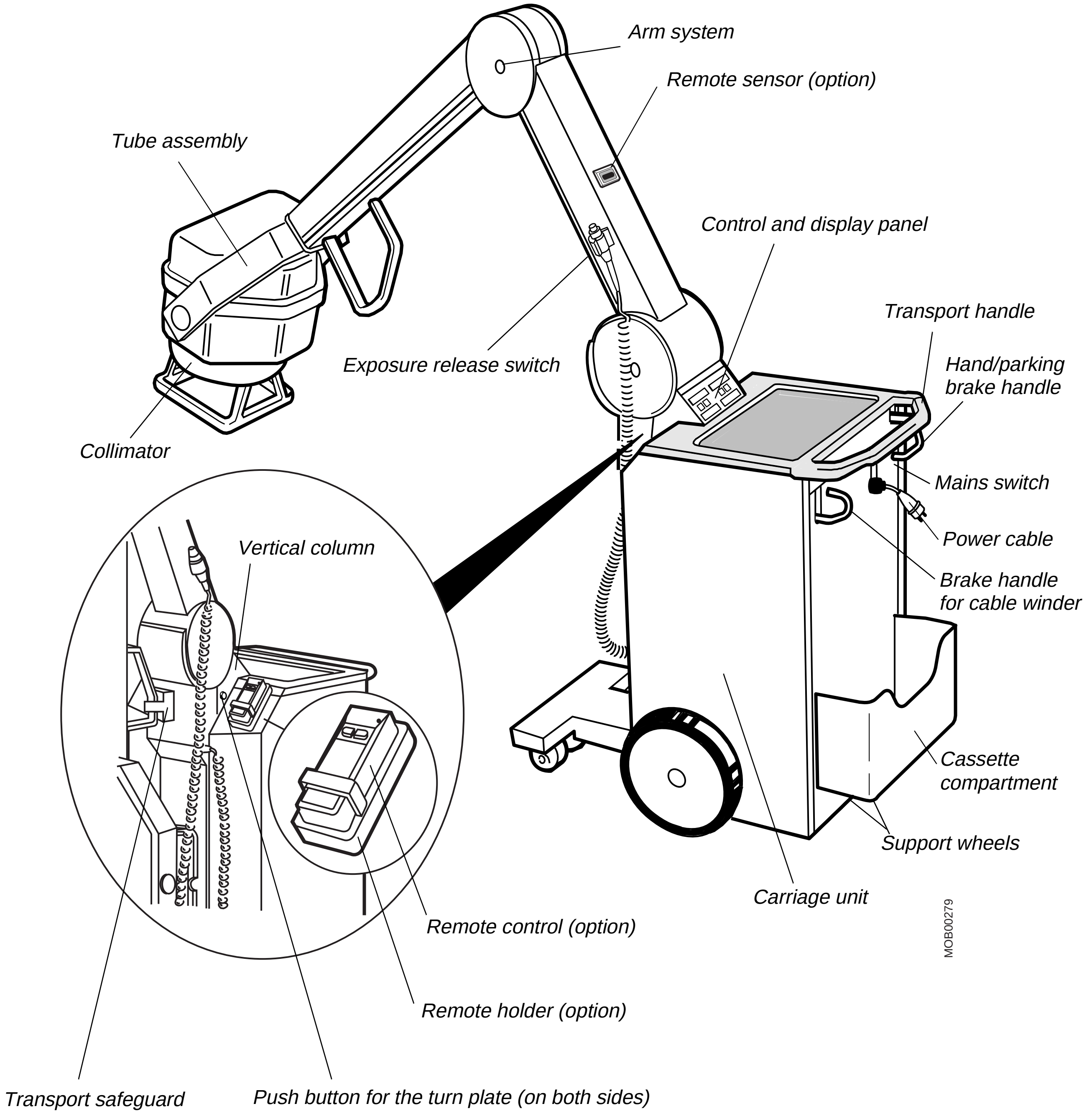

Fig. 1

NOTICE	**MOBILETT Plus from serial number 2800 and MOBILETT Plus E from serial number 10600 are equiped with a cable winder (see Fig. 1).**

Motor driving controls - MOBILETT Plus M only

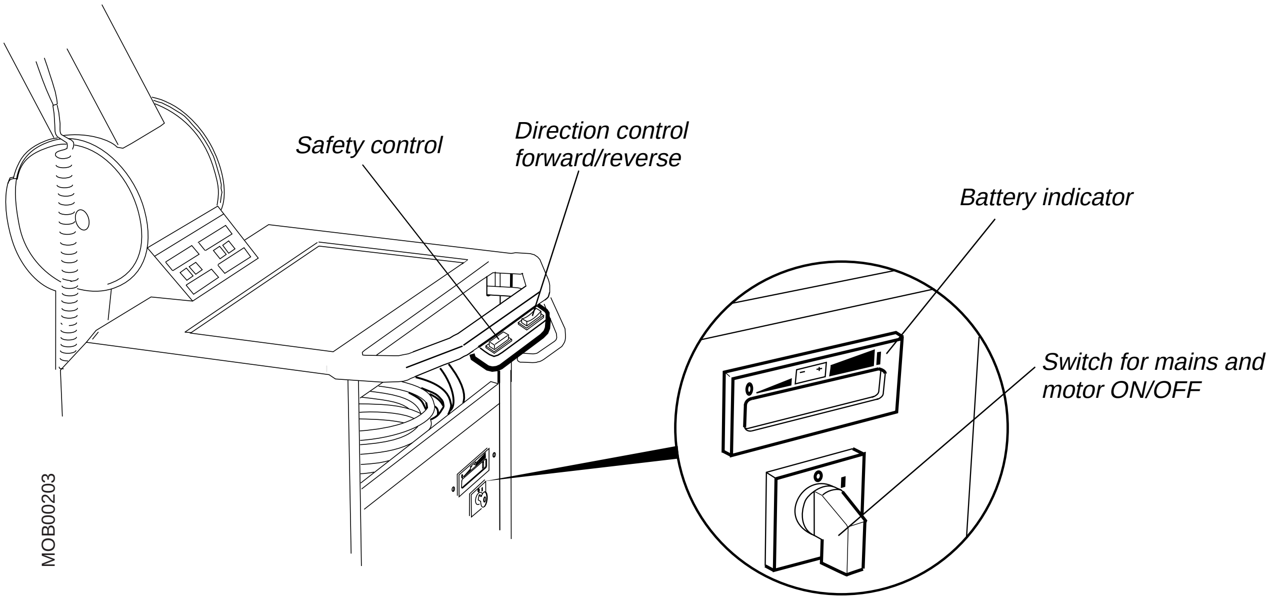

Fig. 2

The MOBILETTs are equipped with a double articulated arm system. The tube is adjustable in both the vertical and radial directions. The flexibility of the articulated arm is the result of a linkage and articulation system. The stability of the articulated arm and tube positions is due to adjustable frictional forces in the joints.

The articulated arm must be positioned and locked in the transport safeguard during transport and parking.

A solenoid actuated turn plate is simplifies the central beam setting and positioning. The unit can easily be manually rotated around its own axis and the position of the articulated arm and tube can be changed without having to change the position of the unit.

A measuring tape can be pulled out from the multileaf collimator and manually adjustable collimator leafs for limiting the area of exposure on the patient and film complete the range of features available for simplifying settings.

The hand brake can be used, when needed, during transport and for securely parking the unit, see Fig. 3

The display with selection buttons, as well as the audiovisual signals, simplify the use of the unit for both medical and technical staff.

The Instructions for use describe the correct operation of the MOBILETTs.

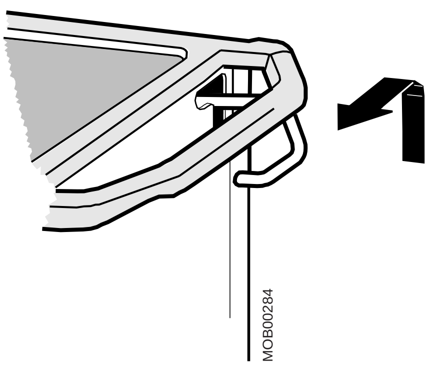

Fig. 3

The block diagrams and the wiring diagram X037E are the basis for the functional description given below.

The block diagram, which you can fold out from front page, is divided into three basic functional areas.

In the ***upper area**,* together with the power-line connection to board D8, are the reference value requests with control panel on board D3 and the actual value signals from the single tank.

In the ***central area*** CPU board D1, on which two microprocessors for signal control and for regulation and monitoring tasks are located, is shown.

As the main processor an SAB 80C535 8 bit processor is used. This implements the user interface and supervises most of the non time-critical signals.

For the supervision of real-time tasks during exposure, such as parameter regulation and monitoring, and for tube current integration to give the mAs product, an SAB 80C166 16 bit microprocessor is used.

In the ***lower area*** the power components and the power consuming components are shown.

- capacitor-charging circuit on board D7
- capacitor bank, M1
- high-voltage inverter on board D13
- multifunction board D4,
  - a) filament-circuit inverter
  - b) anode-plate drive inverter
  - c) collimator-lamp control circuit
  - d) turn-plate control circuit.
- x-ray tube / single tank H1
- collimator lamp in Z66
- turn-plate magnet PM, MOBILETT Plus/ Plus M only

Motor power system block diagram in chapter "MOBILETT Plus M - Motor power system".

The individual boards and components are shown in the form of picture frames.

These contain the component elements and test points, along with a number in italics which indicates on which sheet of the wiring diagram X037E additional detailed drawings of a particular functional unit can be found.

In addition, the cable connections between the boards and the components are given in binding form.

Certain texts from this functional description are marked with this symbol.

These texts describe functional procedures, such as adjustment, calibration, testing or working procedures, which are included as part of a training video. All of these procedures are explained in detail and demonstrated there!

⚠WARNING	**Servicing and maintenance tasks on the MOBILETT is to be performed only by those who have worked through the entire self-training material provided.**

The block diagrams and the wiring diagram X037E, sheet 100, are the basis of the functional description given below.

The unit can be connected to a grounded wall outlet with the power cord

Board D8 is powered from the power-line connection via the power cord and switched on by the mains switch ”S 11”.

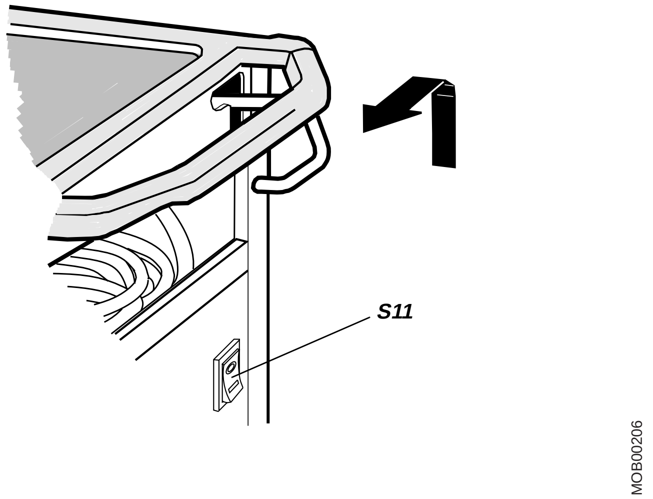

Fig. 1

Fuses U9 and U10, before board D8, protect the power lead-in.

The use of two fuses to protect the single phase power lead-in is required for safety reasons as a result of the worldwide use of the unit.

Any conceivable short circuit current in the unit leads under all circumstances to a blown fuse.

Board D8 can adapt by itself to line voltages between 100 V AC and 240 V AC.

Switching circuitry on this board furnishes a standard primary voltage at transformer T3.

A total of nine secondary windings are available for AC voltages.

- six are fed as DC voltages to the voltage stabilization circuits on boards D1, D3, D4, D7 and D13 as supply voltages.

  They are transformed into the supply voltages required and indicated via the LEDs on these boards.

  The voltages can be checked at the test points with a digital voltmeter or an oscilloscope.
- two are used as AC control voltages for the turn plate (MOBILETT Plus and Plus M only), one also serving as a control voltage for the collimator lamp in the multileaf collimator, Z66.
- one of these secondary voltages is used as an internal supply voltage for board D8 itself.

Board D8 is supplied with the line voltage via the power cord and mains switch "S11".

Board D8 furnishes nine different DC voltages, which are fed to the autonomous voltage stabilization circuits on boards D1, D3, D4, D7 and D13.

There they are transformed into the required supply voltages and displayed via LEDs.

On board D1 the red ”reset” LED lights up briefly, followed by the initialization and self-test.

During this phase, approx. 1 s, the display on the control panel is not lit up.

However, on board D3 the red ”start up” LED is illuminated. This is located at the right, next to the kV display.

Following this:

- the filament circuit on board D4 is activated and the preheating of the filament spiral in the single tank is turned on,
- a braking procedure is initiated for the rotating anode in the single tank,
- the exposure-parameter display on board D3 is activated,

  Preferentially, after the initial message ”HEJ” ”HEJ”, the display will show whatever exposure parameter displayed before the last switch-off of the unit,
- if the start voltage in the capacitor bank, M1, is <10 V, the capacitor bank will be charged to 150 V during the first charging phase.

  After a brief pause of about 5 s, during which the leakage current from the capacitor bank is calculated from the discharge characteristic of the capacitor bank, the second charging phase takes place.
- the final voltage value of the capacitor bank, M1, depends on the exposure parameters displayed.

The final values are:

300 V	with a tube voltage display of < 45 kV
325 V	with a tube voltage display of ⩾ 45 kV and < 50 kV
350 V	with a tube voltage display of ⩾ 50 kV

- The oil temperature in the single tank is measured. If the temperature is not within the range +15°C to +55°C, an error will be displayed.
- The positions of service switches ”S1” and ”S2” on the CPU board D1 are queried.

The switch positions are:

”S1” and ”S2”	off	=	normal mode
”S1”	on	=	software-supported service mode
”S2”	on	=	PC mode

PC mode is used only for testing procedures at the factory!

The exposure parameter display indicates ”PC-Mode” and the selection buttons on the control panel are disabled!

- The charging procedure for the capacitor bank is completed after reaching the final voltage value. According to the residual voltage in the capacitor bank, this takes between 5 and 120 s.
- The green ”ready” LED on the control panels turned on.

The unit is ready to operate!

The block diagrams and the wiring diagram X037E, sheet 130 are the basis for the functional description given below.

The entire charging circuit includes the boards D8, D1 and D7 and the capacitor bank, M1.

MOBILETT Plus and Plus M;

The capacitor bank contains four modules with 26 capacitors in each module. Each single capacitor value is 3100 mF, 360 V. The theoretical capacitance is 0.32 F.

MOBILETT Plus E;

The capacitor bank contains three modules, two with 26 capacitors and one with 14 capacitors. Each single capacitor value is 3100 mF, 360 V. The theoretical capacitance is 0.2 F.

On board D7 three logic signals control the charging of the capacitor bank, M1.

”CHARGE HIGH” for charging with high power

”CHARGE LOW” for maintaining the kV-dependent final voltage attained over the capacitor bank, M1

”DISCHARGE” for the controlled discharge of the capacitor bank, M1.

The voltage of the capacitor bank can be measured with a digital voltmeter at the test points ”CAPPOS” and ”CAPNEG” on board D7.

The actual value of the capacitor voltage is fed with the signal ”CAPVOL” to the CPU board D1. There the value is monitored by the microprocessor SAB 80C535.

The voltage level at ”CAPVOL” determines when the following control signals are issued:

- ”CHARGE HIGH”
- ”CHARGE LOW” and
- ”DISCHARGE”
- ”ready” is used to control the green LED on the control panel.

When the unit is switched on and the self-test and the initialization phase are completed, the charging process in the capacitor bank, M1, is initiated with the control signal ”CHARGE HIGH”.

This signal is fed to the control logic on board D7.

The control logic generates control pulses for the BUCK CONVERTER on board D7 with the appropriate pulse-pause modulation data, which control the charging of the capacitor bank, M1.

The entire charging process, if the initial capacitor voltage is <10 V, takes place in three distinct phases.

If the initial voltage is >10 V, the phases 1 and 2 are omitted.

- Phase 1 charging the capacitor bank to a voltage of about 150 V.
- Phase 2 includes switching off the control signal ”CHARGE HIGH” and measuring and monitoring the voltage value of 150 V reached over a time of about 5 s.
- Phase 3 includes switching on of the control signal ”CHARGE HIGH” and the completion of the kV-dependent charging procedure.

After the charging process, a regulation process, is performed to maintain the final value attain-ed.

The corresponding final values are:

300 V	with a selected tube voltage of <45 kV
325 V	with a selected tube voltage of 45 kV and <50 kV
350 V	with a selected tube voltage of 50 kV

The drop in the capacitor voltage, which may take place during the 5 s pause in phase 2, is a measure of the leakage current of the capacitor bank. If the drop is too large, the control signal "DISCHARGE" is switched on and an error message is shown on the display.

As long as the capacitor bank is being charged with ”CHARGE HIGH” the microprocessor on board D1 can not switch on any other major power consuming device. However, the operating personnel can still request this via a manual switch-on procedure.

In case this is done, such as switching on the collimator lamp or the turn plate, the microprocessor on the CPU board D1 interrupts the charging procedure. ”CHARGE HIGH” is then switched off for the duration of the new routine required.

When the high-power consuming device is switched off, the charging process will be continued with the signal ”CHARGE HIGH”.

In the final phase of the charging process for the capacitor bank the actual value of the capacitor voltage ”CAP VOL” on the CPU board D1 is monitored via a software-controlled window discriminator.

When the actual value exceeds the threshold voltage of U_c - 0.8V, the signal ”CHARGE HIGH” is switched off and the green ”ready” LED on the control panel is turned on, see Fig. 1.

The signal ”CHARGE LOW” is then switched on. This regulates the actual value of the capacitor voltage ”CAP VOL”, with a low charging current up to the desired final value. Then "CAPVOL" will be held at, or slightly above, the reference value by switching off and switching on "CHARGE LOW".

The ”ready” lamp remains turned on as long as the actual value of the capacitor voltage ”CAP VOL” remains within the hysteresis tolerance range of ± 1.2 V, see Fig. 1.

If the capacitor voltage "CAP VOL" is not within the threshold voltage range of ± 1.2 V due to, for instance an unusual large leakage current or another kV selection, the green ”ready” LED on the control panel will be turned off.

The capacitor is then either charged with ”CHARGE HIGH” or discharged with ”DISCHARGE” as required until the actual voltage value ”CAP VOL” of the capacitor bank is within the tolerance range of ± 0.8 V.

The green ”ready” LED on the control panel is then turned on again.

The unit is ready to operate!

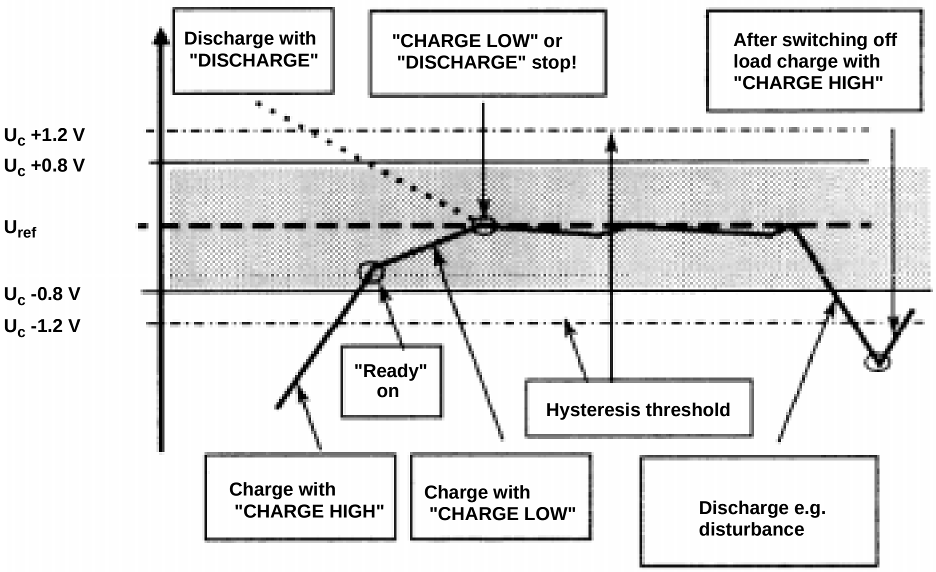

Fig. 1

Charging circuit errors

When an error occurs in the charging circuit function or in the power capacitor the following actions are initiated:

By the buzzer on board D3:

- 10 beep tones are generated
  In addition the green
- ”ready” LED is turned off.
- the parameter display is switched off

The controlled discharge procedure for the capacitor bank is initiated with the

- ”DISCHARGE” signal, and an
- error message is shown in the parameter display.

The discharge procedure for the capacitor bank continues until the fault indicated is switched off by pressing the selection button ”kV+” or by switching off the unit and then switching it on again.

Along with the software-controlled monitoring system for the signal ”CAP VOL” on the CPU board D1 there is also a hardware monitoring circuit on board D7.

This monitors the potential difference across the capacitor bank.

The potential difference between test points ”CAP POS” and ”CAP NEG” is fed via a differential amplifier to a comparator. There the output voltage from the differential amplifier is compared with a threshold voltage of 360V.

If the output voltage from the differential amplifier exceeds this threshold voltage, the signal ”OVERVOLTAGE” will be generated and the LED v12 on board D7 will be lit.

The signal ”OVERVOLTAGE” is fed to the CPU board D1, initiating the routines described above for generating an error message and protecting the capacitor bank.

Other error messages are:

- Voltage rise in capacitor bank too fast,
- Voltage rise in capacitor bank too slow, or
- Leakage current in capacitor bank too large.

Servicing the charging circuit

For safety reasons, before beginning servicing tasks in the charging circuit and in the capacitor bank, the capacitor bank must be fully discharged!

⚠WARNING	**The discharge procedure can be initiated manually with service switch "S10" independently of whether the unit is switched on or off.**

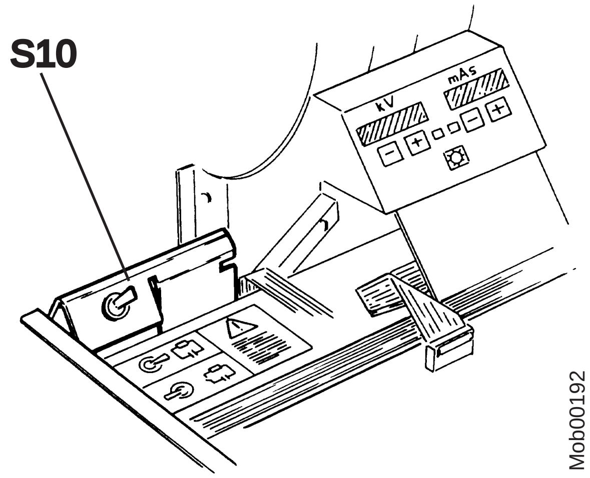

Fig. 2

Closing this switch initiates discharge with a limited discharge current via a resistor pair - including the two resistors R100 + R 101.

It is advisable that you connect a digital voltmeter to test points ”CAP POS” and ”CAP NEG” on board D7 to follow the discharge process.

Perform servicing tasks in the charging circuit and on the capacitor bank only after complete discharge of the capacitor bank!

The electrical energy stored in the capacitor bank for MOBILETTs is given by:

$E = 0.5 \times (350\ V)^2 \times 0.3\ F = 18\ 375\ Ws = 18.375\ kWs$

In case of a short circuit, the energy released is equivalent to that set free by one - ton vehicle colliding with a wall at a speed of about 13.5 mph!

It is therefore necessary to expressly mention here that even a residual voltage of 10 V in the capacitor bank is sufficient in case of a short circuit, such as due to placing a screwdriver across the plus and minus terminals of the capacitor bank, to melt the metal shaft of the screwdriver!

While performing servicing or maintenance tasks on these extremely hazardous components, it is therefore essential that you follow the procedure described in the Service Instructions exactly.

When replacing the capacitor bank or following a long shut-down period of several months, it is necessary to gently and carefully ”form" the entire capacitor bank in order to prevent premature capacitor defects.

For this purpose the software-supported service program ” P06 Capacitor formation ” is available.

The Service Instructions describe how to call this service program.

There are a number of significant power-consuming devices in the MOBILETT. These include:

- capacitor for charging unit D7
- rotating-anode starter on board D4
- lamp in the multileaf collimator, Z66

MOBILETT Plus/Plus M only!

- turn-plate magnet PM

Since the current supplied from the power line is limited, the microprocessor on the CPU board D1 can also allow only limited current consumption.

This means that the software also has the task of distributing and dosing the maximum available current in such a way as to best cover the current requirements in the unit.

At any given time, it must be possible to ensure power to all consuming devices required and at the same time ensure the unproblematic execution of all functions initiated which require a large current without blowing line fuses U9 and U10.

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Selection and display of exposure parameters 9 - 1

The block diagrams and the wiring diagram X037E, sheet 120 are the basis for the functional description given below.

The control circuit for selecting the exposure parameters includes the boards D1 and D3 and the keyboard switch plate N1.

The kV values are selected with the kV selection buttons "kV+” and ”kV-” on keyboard-switch plate N1.

There are different options for parameter selection:

MOBILETT Plus and Plus M;

A with 25 individual steps over a range of 40 – 133 kV in whole exposure points or

B with 49 individual steps over a range of 40 – 133 kV in half exposure points.

MOBILETT Plus E;

A with 24 individual steps over a range of 40 – 125 kV in whole exposure points or

B with 47 individual steps over a range of 40 – 125 kV in half exposure points.

The desired option is selected in service program P14.

The same service program also serves to set the maximum possible selectable kV value in the range from 40 – 133 kV for *MOBILETT Plus and Plus M*, and 40 – 125 kV for *MOBILETT Plus E*.

The mAs values are selected with the mAs selection buttons ”mAs+” and ”mAs-” on keyboard-switch plate N1.

For a given kV, mAs can be selected from 0.5 up to a kV-dependent maximum mAs value.

The maximum selectable mAs value is set in service program P15. The current upper mAs limit is shown in the parameter display, and can be set within the range 0.5 – 200 for *MOBILETT Plus and Plus M*, and the range 0.5 – 100 for *MOBILETT Plus E.*

Note that the kV-dependent maximum mAs value may be lower than this absolute maximum mAs, at a given kV.

The procedure for selecting service program P14 or P15 is described in the Service Instructions.

The selected exposure parameters are shown on the display on the control panel.

Briefly pressing a selection button results in an incrementation/decrementation of the exposure parameter.

Holding a selection button depressed results in an increase/decrease of the exposure parameter, at first slowly and then faster.

On reaching the minimum value of 40 kV or the preset maximum kV value, the kV increase/decrease automatically stops.

In the same way, on reaching the minimum mAs value or the maximum mAs value for this kV, the mAs increase/decrease automatically stops.

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MOBILETT Plus and Plus M only

The block diagrams and the wiring diagram X037E, sheet 170 are the basis for the functional description given below.

The turn-plate control circuit includes the boards D8, D1 and D4 and the turn-plate magnet PM.

The turn-plate magnet is controlled with the two signals ”PIVOT ON” and ”PIVOT HOLD”.

It is possible to measure both signals on board D4.

The turn plate can be controlled by either one of the two turn-plate buttons, located at the left and right sides of the vertical column.

Pressing one of the buttons activates the control signal "PIVOT ON", and a lamp lights up in both control buttons.

Turn-plate magnet switch-off also takes place by activating one of the two control buttons, then the lamps in the buttons are turned off.

The signal ”PIVOT ON” controls the relay MR1 on board D4, switching an AC voltage from board D8 to a rectifier on board D4.

This supplies the turn-plate magnet coil with a voltage of about 23.5 V DC. A relatively high current surge of about 20 A results. This in turn activates the turn plate magnet.

By means of a system of levers and springs the resulting magnetic force presses the turn plate, located beneath the generator, against the floor.

In order to reduce the current drawn from the power line without letting the system of levers and springs fall back into its starting position the microprocessor on the CPU board D1 switches off the signal ”PIVOT ON” and switches on the signal ”PIVOT HOLD”.

The contact in relay MR1 then returns to its original position and the contact in relay MR2 is switched on.

MOBILETT Plus and Plus M only

This supplies the turn-plate magnet coil with a lower voltage of about 8 V DC.

The magnetic force resulting in the turn-plate magnet is somewhat greater than the opposing forces in the turn plate's system of levers and springs. This holds the turn plate in position.

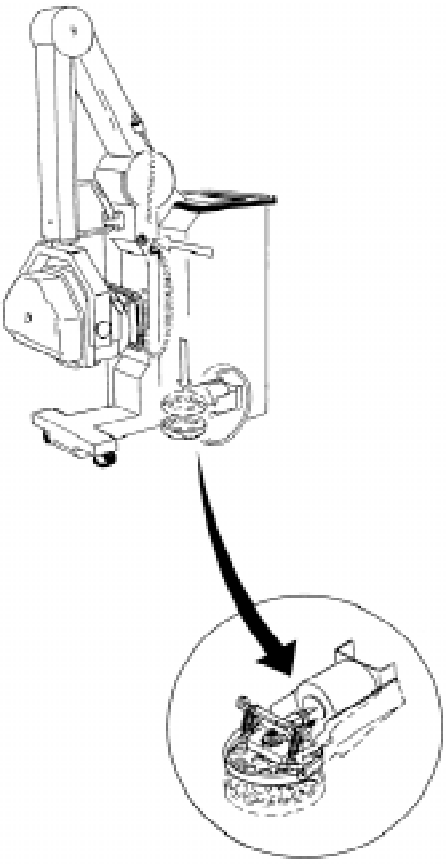

Fig. 1

The magnetization current surge in the turn-plate magnet coil following energizing the relay MR1 with the signal ”PIVOT ON” can be measured with a current probe in cable K 68.

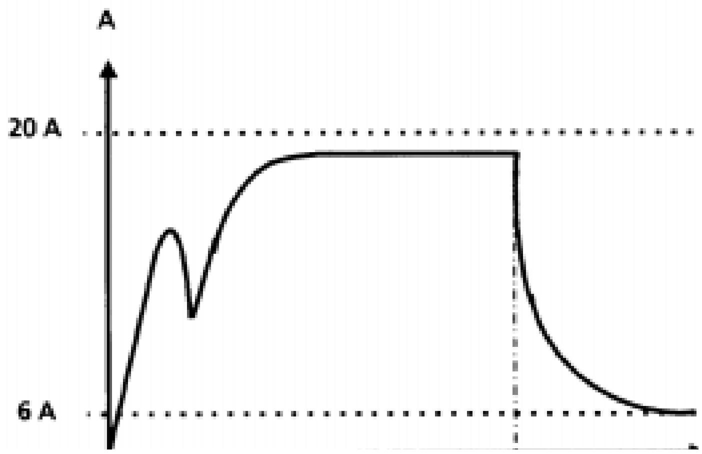

Fig. 2

Collimator-lamp control

The block diagrams and the wiring diagram X037E, sheet 180 are the basis for the functional description given below.

The control circuit for the halogen collimator lamp in the multileaf collimator includes the keyboard-switch plate, N1, the boards D3, D1, D8 and D4 and the multileaf collimator, Z66.

The collimator lamp is controlled by two switches.

- one switch is located directly on the multileaf collimator,
- the other switch is on the keyboard-switch plate N1 beneath the control panel.

The two control signals from these switches are handled and processed independently by the microprocessor on the CPU board D1.

When one of the switches is pressed, the microprocessor on the CPU board D1 generates the control signal ”LAMP ON” for the control relay ”LR1” on board D4. It is possible to measure this control signal on board D4 at the test point ”LAMP ON”.

When control relay ”LR1” makes contact, an AC voltage of about 22 V is supplied to the collimator lamp. This is the same 22 V signal used following rectification to switch on the turn plate.

In case the collimator lamp is switched on during the charging of the capacitor bank, M1, before the signal ”CHARGE HIGH” is finished, the charging procedure is interrupted for about 1 s and then resumed again - as long as the filament of the lamp is still ”cool”.

Either of the two control switches can be used to switch off the collimator lamp.

If the collimator lamp is not switched off in this way, after 30 s the microprocessor on the CPU board D1 will switch it off. The lamp is also automatically switched off after an exposure.

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The block diagrams and the wiring diagram X037E, sheets 120, 130, 140, 150 and 160 are the basis for the functional description given below.

When the unit is switched on the initialization routine and charging of the capacitor bank, M1 starts and the green ”ready” LED on the control panel is turned on.

The unit is ready to operate!

The user can now freely select the exposure parameters with the selection buttons ”kV+”, ”kV -”, ”mAs+” and ”mAs -” to meet the requirements and the appropriate limiting values of the examination.

Following alignment of the central x-ray beam and definition of the area to be x-rayed by the multileaf collimator onto the target object, the exposure can be prepared and released.

Exposure preparation

The primary contact in the exposure-release switch is first closed. This initiates the following functions:

1. switches off the preheating,
2. switches on the exposure heating,
3. starts the two second rotating-anode acceleration,
4. if the anode frequency after acceleration is >147[1] Hz, the buzzer on board D3
5. generates three beep tones, and
6. the green ”ready” LED on the control panel is turned on.

1. 142 Hz if FW version lower than 1.5 or 1.5E.

Exposure release

The secondary contact in the exposure-release switch is closed. This initiates the following additional functions:

- the yellow exposure-indicator lamp on the control panel is turned on,
- the high-voltage inverter is switched on,
- the resulting tube current is integrated until the preset mAs value is reached, followed by;
- the high-voltage inverter is switched off,
- preheating is resumed
- a long beep tone is generated.
- the exposure-indicator lamp is turned off.
- the rotating anode is braked.

NOTICE	**If the MOBILETT Plus is equiped withe a remote exposure switch system, please see Installation Instruction: Installation of remote exposure switch system, chapter 3 "Supplement to the Instructions for Use".**

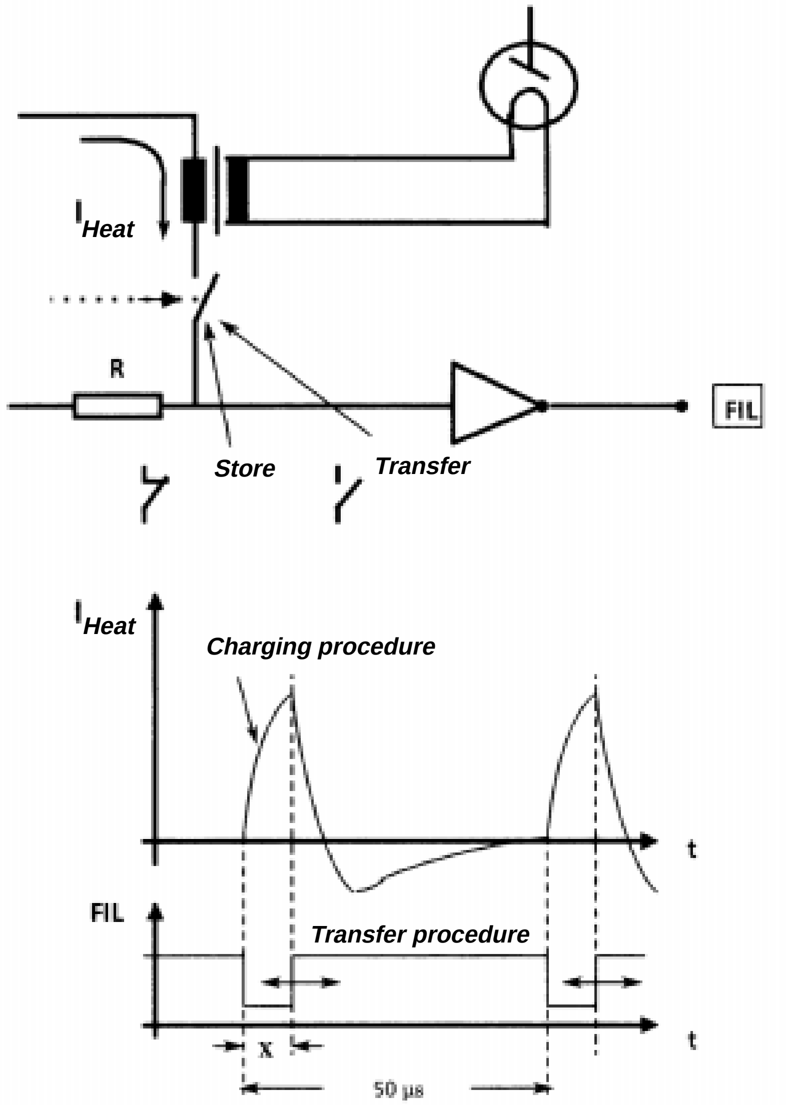
The block diagrams and the wiring diagram X037E, sheet 160 are the basis for the functional description given below.

The filament circuit includes boards D1, D4 and D8 and the single tank, H1.

The filament circuit is controlled by SAB 80C166 on the CPU board D1.

The filament heating of the x-ray tube takes place by means of pulse-width modulation of the heating-energy transmission.

This is based on charging a heating transformer over a variable time ”X” and then transferring the energy to the filament.



Pulse width X = approx. ***6 µs*** in ***"stand by mode"***
Pulse width X = approx. ***20-30 µs*** in ***"preparation or release mode"***

Fig. 1

This pulse-width modulated signal can be measured at test point "FIL" on board D4 and is used to control a MOS-FET on board D4.

The MOS-FET is connected in series with the filament transformer in the single tank, H1.

This MOS-FET supplies the filament transformer with regulated current pulses having a frequency of 20 kHz.

The voltage of the current source can be measured between the test points "60 VDC" and "60 V DC RET" on board D4. The actual value of this voltage can be measured at test point "FILVOL" (1 V/14 V) on the CPU board D1.

A measuring resistor on board D4 measures the primary filament current.

The voltage drop, occurring across the resistors, is fed after a filtering to the CPU board D1.

The filtered measured value can be measured at test point "FIL VAL" on the CPU board D1 as a representative IH_{actual} in the filament of the X-ray tube.

In "stand by mode" the X-ray tube filament is heated with the so-called "preheating". In this mode, it is possible to measure a pulse time of 6 µs at test point "FIL" on board D4.

The actual filament current value signal "FIL VAL" is measured and monitored every 52.5 ms by the microprocessor on board D1.

In "stand by mode" the signal "FIL VAL" must be between the limits 0.16 – 2.5 V.

If this measured value is outside of the predefined monitor limits,

- the filament circuit will be immediately disabled,
- the green "ready" LED on the control panel will be turned off, and
- an error message will be shown in the parameter display.

In "preparation mode" (with the primary contact of the exposure release switch closed) the pulse width modulation is changed.

The pulse width for the trigger signal "FIL" on board D4 is continuously increased to a value of about 20 - 30 µs, and then held constant.

The pulse width value used in the preparation depends on the selected kV value. In the CMOS memory there are two tables with values, one contains fixed start values and the other one contains the self adapted values of the generator.

The fixed values are only used when there is no table with adapted values. In that case, the table with fixed values is copied into the table for adapted values.

Later the table will be adjusted and optimized to correspond to the individual generator and X-ray tube.

In preparation mode, the signal "FIL VAL" must comply with three conditions in order to avoid an error message:

1. The voltage level of the signal "FIL VAL" must be within a certain tolerance range.

   A filament current reference is derived from the adapted pulse-width value for the selected kV value.

   Due to the individual differences in the filament current characteristic within the X-ray tube series used in the single tank, the tolerance for "FIL VAL" is defined to be ±0.6 V.

2. The voltage level of the signal "FIL VAL" must be stable.

   The voltage level of the signal "FIL VAL" is measured during a time of 3 s maximum, periodically every 13 ms. If the difference between two consecutive values for all of the last 20 values measured is <0.1 V, the signal "FIL VAL" is regarded as stable.

   As soon as the stability of the voltage level of "FIL VAL" is verified, the current voltage level of "FIL VAL" is assigned as the new reference value.

   The filament program then changes to the "holding mode".

3. In this mode the signal "FIL VAL" must remain within the tolerance range of ±0.12 V, relative to the reference value.

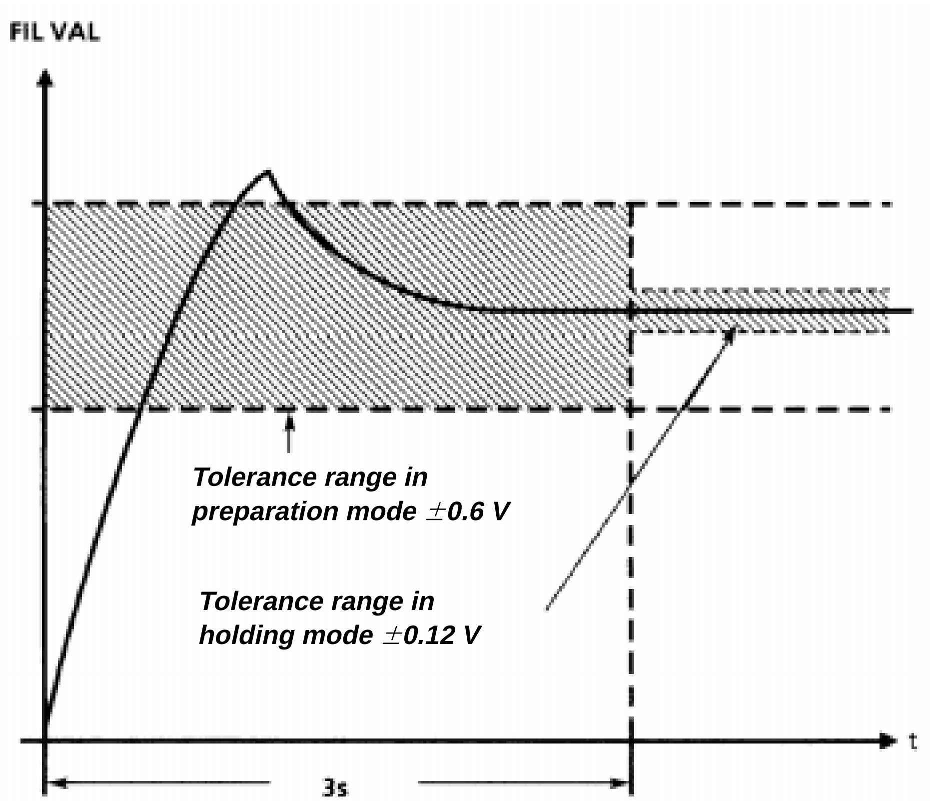


Fig. 2

Filament circuit faults

When a fault occurs in the filament circuit, the following actions are initiated:

The buzz on board D3

- generates 10 beep tones,
- the green ”ready” LED on board D3 is turned off,
- the parameter display is switched off,
- the filament current is switched off,
- an error message is shown in the parameter display.

The error message can be acknowledged by pressing the ”kV+” selection button.

If this fails to switch off the error message, proceed according to the Service Instructions!

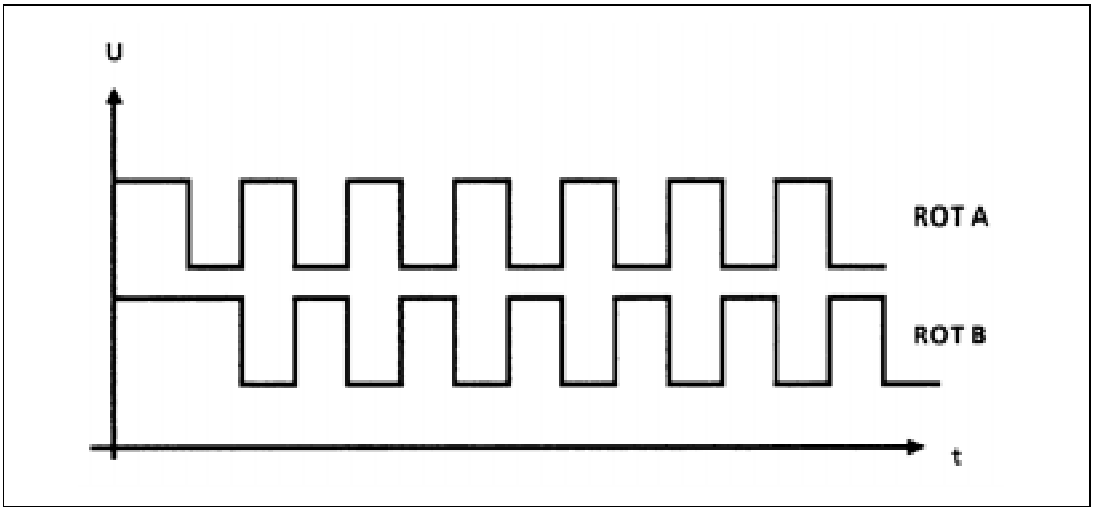


Fig. 1

The block diagrams and the wiring diagram SPR8-220.051..., sheet 150, are the basis of the functional description given below.

The circuit for the rotating-anode consists of the boards D1, D4 and D8 and the stator of the single-phase asynchronous motor of the rotating anode in the single tank, H1.

The inverter for the rotating anode has four POWER MOS-FETs as a square wave inverter on board D4.

The inverter is supplied with 100 V DC from board D8.

This voltage can be measured between the test points "100 V DC" and "100 V DC RET" on board D4.

The inverter on board D4 is controlled by the SAB 80 C535 CPU on D1. Two180° phase-shifted signals (fig.1) "ROT A" and "ROT B" on board D4 generate the speed for the rotating anode with a boost of power in a time of 2 s.

The power from the inverter feeds the two windings of the single-phase asynchronous motor via the cable "K61".

A phase-shift capacitor is in series with the auxiliary winding of the motor. The phase-shift capacitor connects via cable "K66" board D4 and the auxiliary winding of the motor.

The phase shift between main and auxiliary winding is 90°. This is necessary to enable rotation with the maximum torque.

To get the rotating anode up to speed a control signal with a frequency of 160 Hz[1] is applied to the two test points "ROT A" and "ROT B" on board D4.

The run-up-time requires two seconds. After this the control signal is switched off and the anode runs freely. If the anode looses speed and a frequency <147 Hz[2] is measured, the anode is accelerated for 0,75 s. These additional "pushes" are repeated, if necessary, until the limit of the preparation time (20 s[3]) or until the release of an exposure. A push is interrupted if an exposure signal is made.

The free running anode motor acts like a generator. It produces a remanence voltage which is detected by a transformer on board D4.

1. 150 Hz if FW version is lower than V1.5 or V1.5E.
2. <142 if FW version is lower than V1.5 or V1.5E.
3. 10 s if FW version lower than V1.2 or V1.2E.

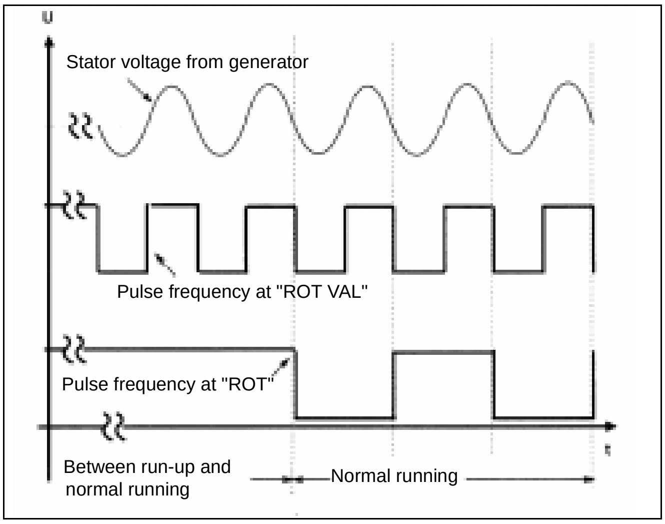


Fig. 2

The frequency of this voltage represents the momentary speed and it is monitored from the CPU during the entire free run. The frequency reached can be checked (fig.2) at "ROT VAL" on board D4 or at "ROT" on board D1.

At test point "ROT", on the CPU board D1, the time between two pulse edges is the time for a complete sinusoidal oscillation.

The pulse frequency is divided by 2 at test point "ROT" on D1. It is monitored at the same time from the CPU on D1.

The anode is up to speed if the pulse frequency "ROT" is > 147 Hz[1] after the run-up-time of 2 s.

If the frequency detected is below 147 Hz[1] the entire run-up procedure will be repeated and the reached speed will be measured again.

If the second try indicates that the required speed of 147 Hz[1] is now exceeded, the control system generates the internal message "anode up to speed"! This completes the preparation together with exposure heating on.
The green "ready" LED on the control-panel turns on and the buzzer generates three beep tones.

The unit is now ready to operate!

After the exposure is terminated the anode-braking procedure starts. This is done with a pulse frequency of 1.667 kHz by the CPU on board D1. It can be measured on test point "ROT A" at board D4.

This frequency generates by one pair of MOS-FETs in the inverter a pulsed DC current for both stator windings.

The magnetization in the stator and rotor winding produces an eddy current field which slows down the speed of the rotor. The brake time to a full stop takes 9 s[2].

The braking procedure for the rotating anode is also active under following circumstances:

- when switching on the unit,
- if the operator interrupts an exposure preparation, or
- if a system fault occurs.

1. 142 Hz if FW version lower than V1.5 or 1.5E.
2. 7 s if FW version lower than V1.4 or V1.4E.

The block diagrams and the wiring diagram X037E, sheet 140 are the basis for the functional description given below.

The high voltage circuit includes:

- the capacitor bank, M1,
- the CPU board D1,
- the high-voltage inverter board D13,
- the single tank H1

The high-voltage inverter on board D13 includes eight power MOS-FETs and functions as a square wave inverter.

It is supplied with power from the capacitor bank, M1, with power and with control pulses in the frequency range 20 - 50 kHz to control its function from microprocessor SAB 80C166 on the CPU board D1.

The pulse-pause ratio of this control frequency is modulated by the microprocessor on the CPU board D1.

It is possible to measure the control frequency at the test points ”INV A” and ”INV B” on board D13.

The high-voltage inverter drives a DC voltage of alternating polarity via the primary winding of the single tank H1.

The secondary winding of the single tank H1 transforms these current pulses into high voltage and a voltage doubler circuit generates their final value.

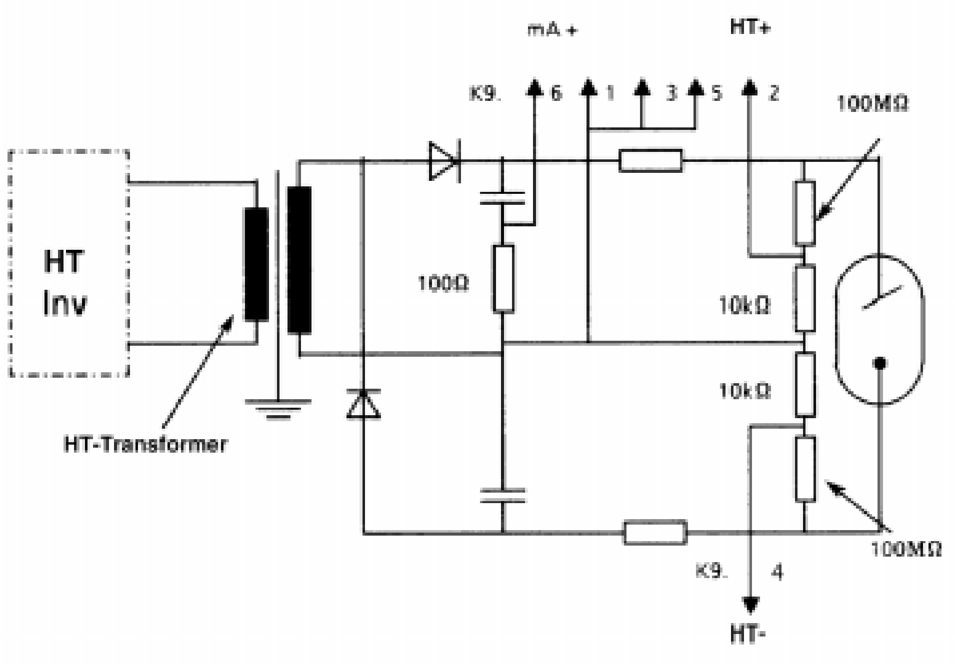


Fig. 1

At the start of an exposure, the high-voltage inverter on board D13 is controlled by a pulse frequency of 50 kHz.

This frequency is continuously decreased during 0.7 ms to 20 kHz, or 25 kHz (<60 kV). This frequency is held during the rest of the exposure.

The frequency scan during the exposure start is intended to limit the inverter current.

By means of measuring resistors in the single tank, the actual high voltage values at the anode and cathode ”HT+” and ” HT-” are fed to operational amplifiers on the CPU board D1.

The outputs of these signals can be measured at test points ” HT POS” and ”HT NEG”.

These two signals are converted by means of a differential amplifier into the signal ”HT” and by means of a summation amplifier into the signal ”HTD”.

The signal ”HT” represents the voltage drop across the X-ray tube in the single tank.

It is transformed via another amplification circuit into the peak value of the tube high voltage ”HT PEAK”.

The signal ”HTD” represents the difference between the two high voltage signals ”HT POS” and ”HT NEG”.

The high voltage signal levels are as follows:

”HT POS”	+1 V / 10 kV
”HT NEG”	–1 V / 10 kV
”HT”	+1 V / 40 kV
”HTD”	±1 V / 40 kV
”HT PEAK”	+1 V / 40 kV

The microprocessor 80C166 on the CPU board D1 measures the signal ”HT PEAK” every 150 µs. The measured values are used as input to the feedback-control of the tube voltage.

The tube voltage is controlled by pulse-width modulation of the high-voltage inverter control signals, and of the filament-control signal.

The values of "HT PEAK" are checked to be within its tolerance range of ±5 kV with reference to the selected kV value.

The signal "HTD" is also checked against its limits of ±20 kV.

The maximum values of the signals "HTD" and "HT" are defined as follows:

"HTD"	±20 kV
"HT"	140 kV

High - voltage signal ”HT PEAK” curve for a short - time exposure of about 2.5 ms.

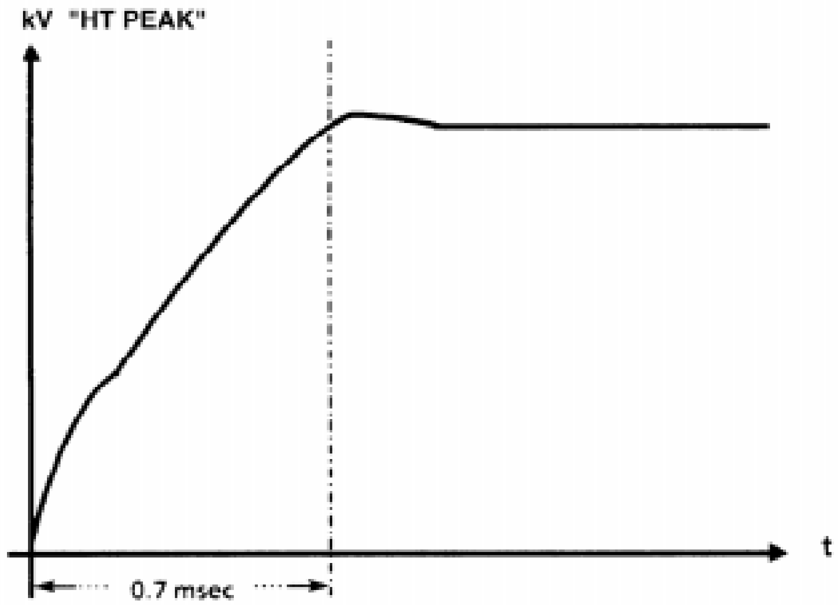


Fig. 2

The current converter T3 on board D13 picks up the high-voltage inverter current passing through the high-voltage transformer in the single tank, where it is checked by a comparator with reference to a threshold voltage value corresponding to a current of max. 290 A.

If the high-voltage inverter current exceeds this threshold value — such as due to a surge or a discharge in the tube of the single tank — the signal ”OVERCURRENT” is generated at the output of the comparator.

This signal is then fed to the microprocessor SAB 80C166 on the CPU board D1, which interprets the signal as an error message.

High-voltage circuit errors

The following events in the high-voltage circuit lead to the generation of an error:

- HT PEAK > ±5 kV outside the selected kV value
- HT >140 kV
- HTD >±20 kV
- OVERCURRENT resulting from a high-voltage inverter current of >290 A.

The unit reacts as follows to an error in the high-voltage circuit:

- the signals ”INV A” and ”INV B” are disabled,
- the green ”ready” LED on the control panel is turned off,
- the rotating anode brake is switched on,
- the exposure heating is switched off,
- the preheating is switched on, and
- in the parameter display an error message is shown.

The error message displayed can be acknowledged by pressing the selection button ”kV +”.

If the same error message appears again proceed according to the Service Instructions!

The block diagrams and the wiring diagram X037E, sheet 140 are the basis for the functional description given below.

The actual tube current is led via a measuring resistor in the single tank and cable K9 to the CPU board D1.

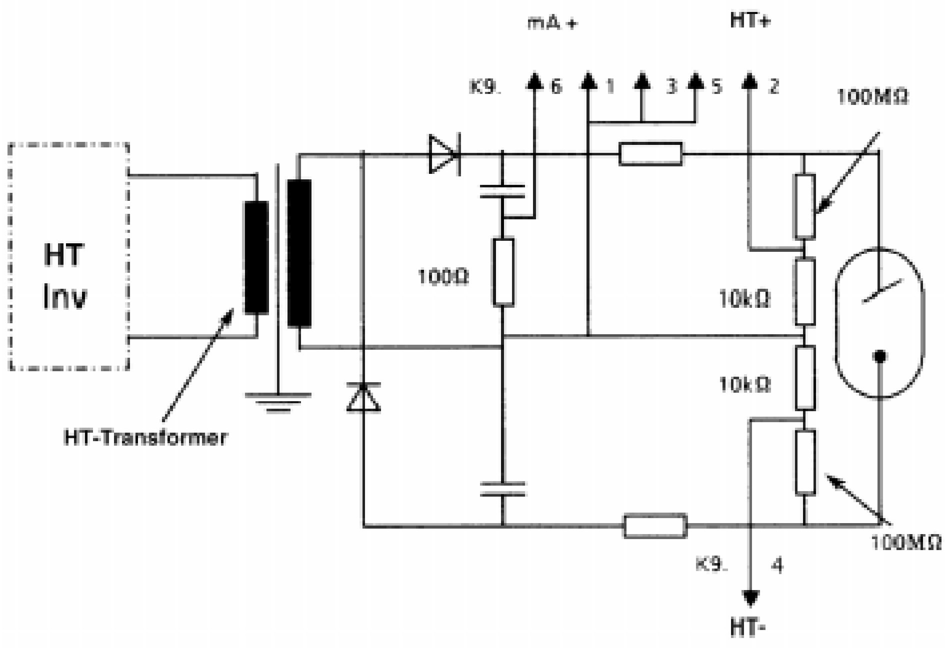


Fig. 1

There it can be measured at test point ”MA POS”.

Before the exposure release the selected mAs value is stored as binary information in a software-implemented counter.

Beginning 0.7 ms after the start of exposure the actual tube current ”MA POS” is measured every 50 µs by the microprocessor 80C166 on the CPU board D1 until the exposure is completed.

The result of the measurement is used to decrease the counter.

Simultaneously, each measured actual tube current value is compared with a minimum value of 5 mA.

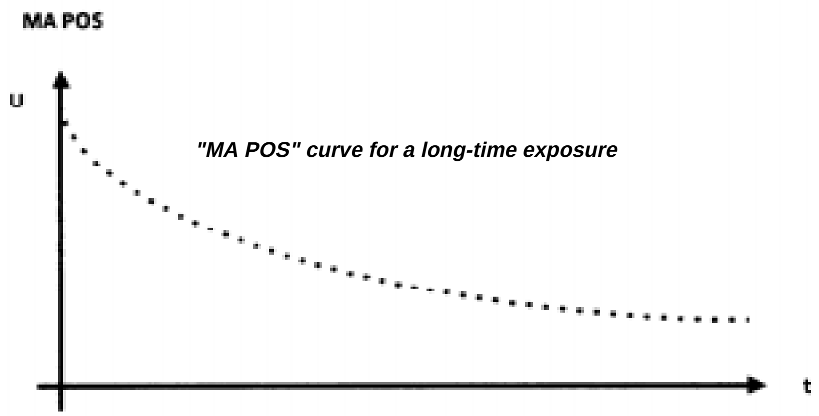


Fig. 2

The selected mAs value is reached, as soon as the counter has been reduced to zero.

The two control frequencies at test points ”INV A” and ”INV B” on board D13 are then disabled.

This switches off the high-voltage inverter.

The following further actions are then initiated:

- the yellow exposure-indicator lamp is turned off,
- the buzzer on board D3 produces a relatively long beep tone,
- the rotating anode is braked for about 9[1] seconds, and
- the green ”ready” LED on the control panel is turned off.

When the anode plate comes to rest, the capacitor bank, M1, is charged again.

When the signal ” CAP VOL” has reached its kV- dependent final value, the green ”ready” LED is turned on. The unit is ready to make new exposures.

The following oscillogram shows, as an example:

CH 1 = ” HT PEAK” at 60 kV

CH 2 = ” MA POS ” at 100 mAs

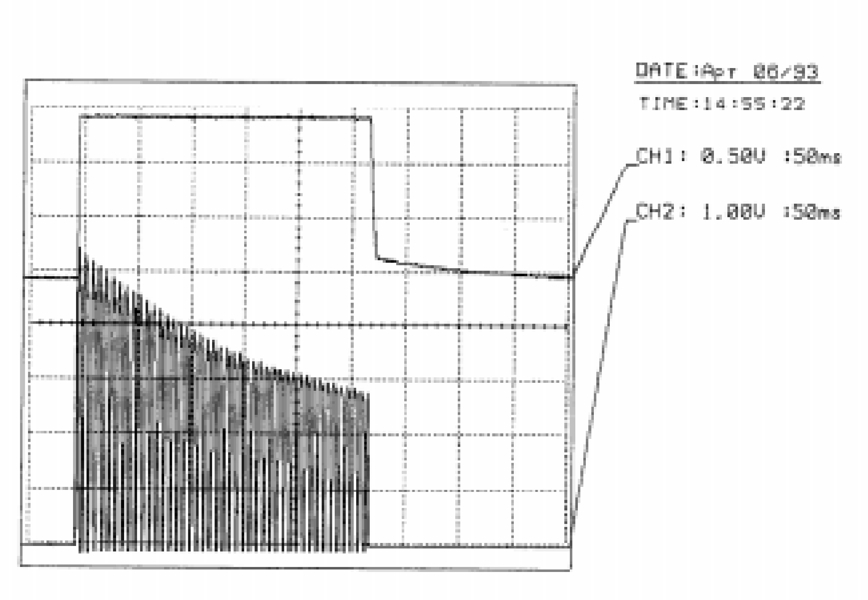


Fig. 3

Here, only the ”envelope” of ”MA POS” is important, since measurement with a digital oscilloscope, due to the ”sample rate” of the oscilloscope, can distort the individual pulse forms shown in the display (aliasing effect)!

See the Service Instructions for additional information!

1. 7s if FW version lower than V.1.4 or V.1.4E.

Tube current circuit errors

If, however, the microprocessor 80C166 on the CPU board D1 determines after several consecutive measurements that the actual tube current ”MA POS” is below the minimum value of 5 mA, will be interpreted as an error message.

The unit then reacts as follows.

- the signals "INV A" and "INV B" are disabled,
- 10 beep tones are generated by the buzzer on board D3,
- the yellow exposure-indicator lamp is turned off,
- the exposure heating is switched off,
- the preheating is switched on,
- the rotating anode is braked for 9 s[1],
- an error message number is shown in the parameter display.

This error message number can be acknowledged by pressing the selection button ”kV+”. If the problem occurs again when repeating the exposure, proceed according to the Service Instructions.

1. 7s if FW version lower than V.1.4 or V.1.4E.

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The block diagrams and the wiring diagram X037E, sheet 140 are the basis for the functional description given below.

The tube-loading calculation is performed by the 80C535 microprocessor on CPU board D1.

It fulfills two tasks:

1. it prevents the thermal loading of the anode plate from exceeding a maximum of 80 % of the permissible loading (in HU = Heat Units) and
2. it limits the long-term (one hour) mean value of the X-ray tube heat reduction to 73 W.

This makes use of a so-called HU memory, in which the heat units calculated from the kV and mAs values used in each exposure are summed.

The memory contents are continuously compared with a HU limiting value of about 80% of the permissible thermal loading in HU.

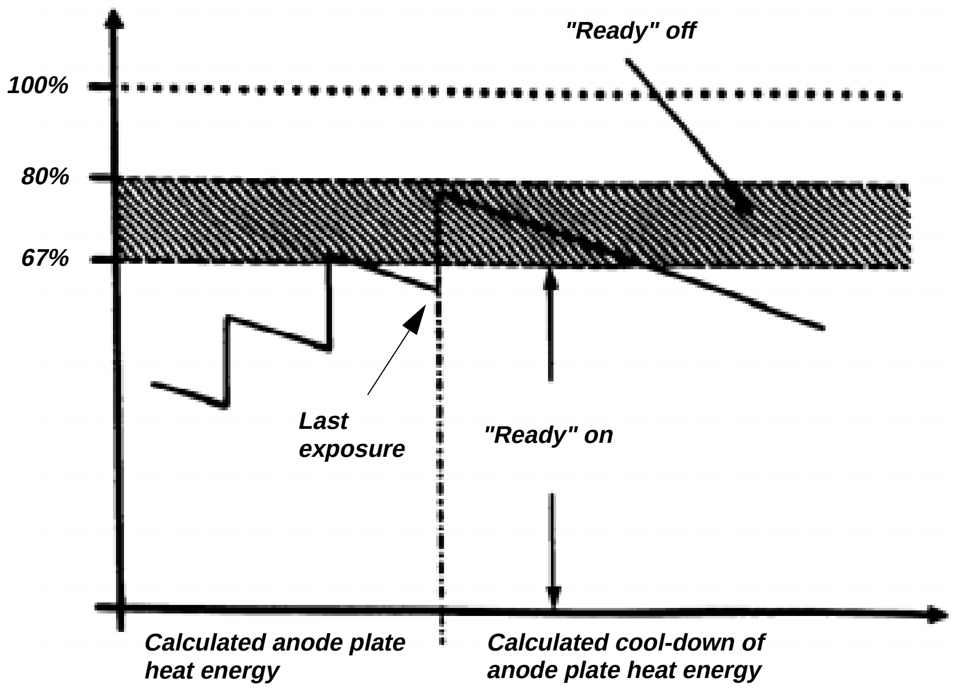

Fig. 1

Between exposures, the contents of the HU memory are reduced by 13 Joules every 250 ms in order to simulate the cool-down characteristic of the X-ray tube assembly. 13 Joules represent about 52 W cooling capacity.

The actual cooling curve is somewhat steeper than the calculated one.

If, following the last exposure, the calculated anode-plate heat energy is larger than 67 % of the permissible thermal loading in HU, a new exposure is not allowed. Then the green ”ready” LED on the control panel is turned on again, allowing a new exposure, only after the calculated anode-plate heat energy is again below the limiting value of 67%.

This ensures that the thermal loading will never exceed 80%.

A special algorithm in the microprocessor software ensures that:

1. the maximum anode-plate heat energy can never become larger than 67 % of the permissible thermal loading in HU + the maximum increase in thermal loading from an exposure and
2. the mean X-ray tube power can not exceed 73 W during one hour.

NOTICE

To be able to calculate the cooling curve, the MOBILETT must be switched on. This means that if the MOBILETT, during the day has been used for a large numbers of exposures, the operator must leave the device turned on for 10 to 20 minutes so that the HU-memory can be emptied.

Error messages

If the units monitoring system detects a fault during the execution of a function, a message will be shown in the parameter display on the control panel.

There are three types of error messages.

- messages with the designation ”ERR”
- messages with the designation ”CAL”, and
- messages with the designation ”USE”.

Messages with the designation ”ERR” indicate an erroneous parameter - e.g. when tolerance limits are exceeded.

Messages with the designation ”CAL” indicate a fault in the execution of a function or that important necessary conditions for the correct execution of individual functions in certain partial ranges no longer exist.

Messages with the designation ”USE”, while they indicate the incorrectness of a parameter or of the execution of a function.

In any case, all three error types cause the:

- interruption of the routine just performed,
- several (10) beep tones generated by the buzzer on board D3 to signal this interruption,
- switch-off of the green ”ready” LED on the control panel
- if an error has occurred in the charging circuit for the capacitor bank, initiation of a capacitor discharge procedure.

The normal function of the buttons on the control panel is then disabled.

The error message can be acknowledged by pressing the selection button ”kV+”. If several faults occur simultaneously, it may be necessary to press the selection buttons several times to return to normal function.

The capacitor bank is then charged again.

When the kV - dependent final value of the capacitor potential is reached, the green ”ready” LED on the control panel is also turned on again.

The unit is ready to operate.

Details concerning the meaning and elimination of error messages are given in the Service Instructions!

All of these messages are stored in a so - called ”Error-history memory”, where they are available at any time for later analyses during servicing.

In the error-history memory a maximum of 20 error messages can be stored.

The error history memory can be called up with the service program ”P08” and cleared with program ”P09”.

The selection procedure and details concerning the service programs mentioned are given in the Service Instructions.

The tensile forces acting in the articulated arm are balanced with a spring counterweight.

The weight of the single tank, its supporting fork and the upper arm, are transmitted by:

- the lever in the upper arm joint,
- the bar and
- the lever in the lower arm joint to the draw bar in the shaft of the arm, see Fig. 1.

The spring between the slide stop and the support ring compensates a constant tensile for the component.

The pressure on the roller of the shaped piece in the lower end of the arm shaft compensates those variable tensile force components arising due to different arm and single tank positions.

The tension of the spring plate in the spring pack can be varied with the adjusting screw.

⚠WARNING **Due to the enormous tensile and compressive forces acting in the articulated arm system, follow the procedures exactly as described in the Maintenance Instruction or the Service instructions when performing repairs or adjustments.**

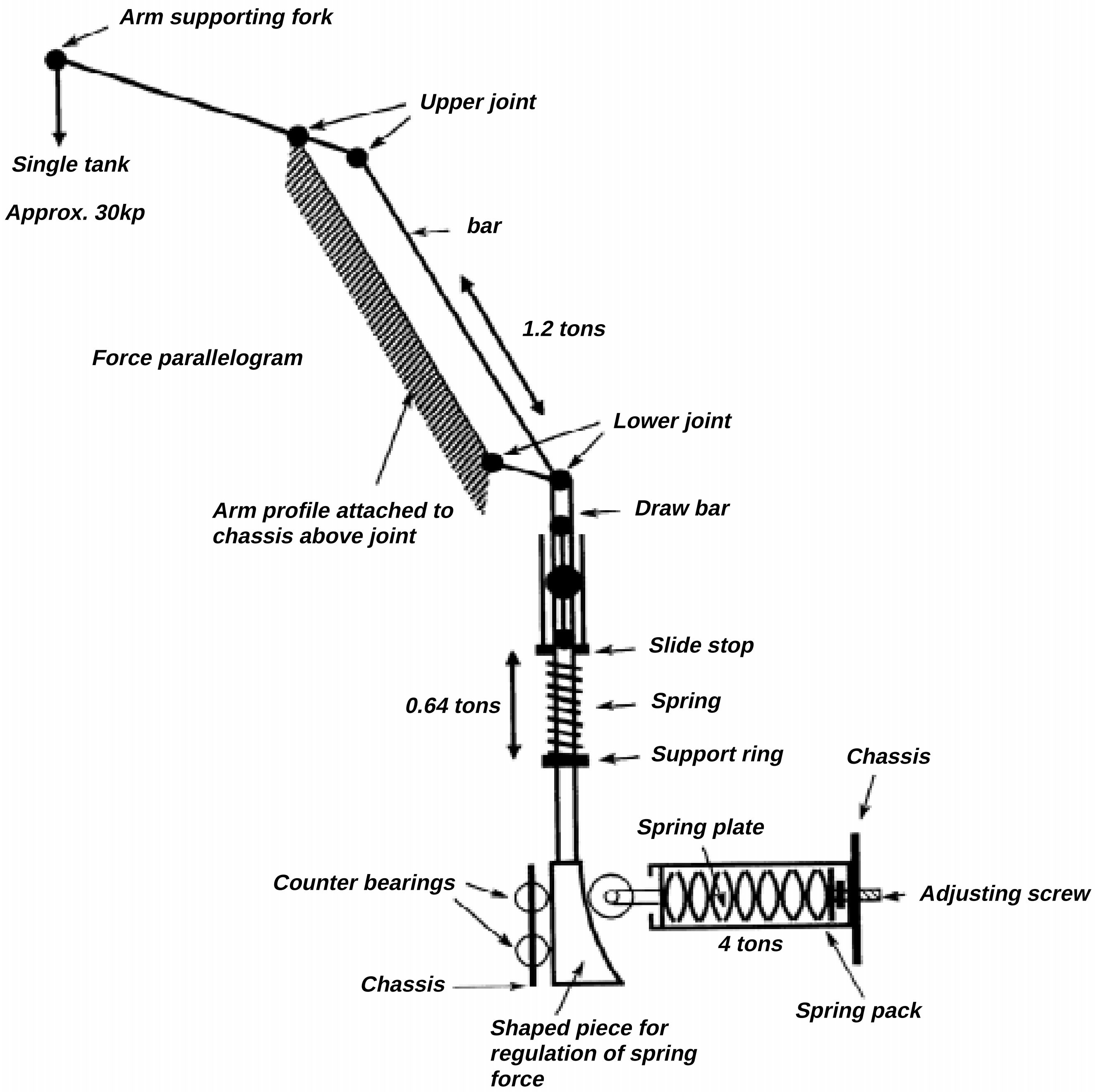
Arm supporting fork
Upper joint
Single tank
Approx. 30kp
bar
1.2 tons
Force parallelogram
Lower joint
Arm profile attached to chassis above joint
Draw bar
Slide stop
0.64 tons
Spring
Support ring
Chassis
Spring plate
Counter bearings
Adjusting screw
4 tons
Chassis
Spring pack
Shaped piece for regulation of spring force

Fig. 1

MOBILETT Plus M only!

The motor power system supplies the MOBILETT with motor power. The operation is controlled by the user through the forward/backward switch and the enable switch. The motor power is switched on by turning the mains switch to 1. With the mains switch in position 0 and the mains cable attached the batteries are charged.

The motor power system consists of motors with power transmission, signal connection board, motor control board, battery charger board, batteries, battery indicator and user controls (i.e. enable switch and forward/reverse switch). The motor control board, the battery charger board and the signal connection board are all located in the motor power unit D101.

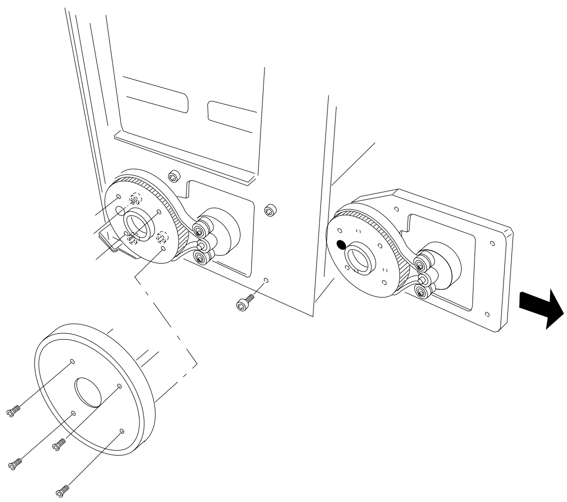

Fig. 1

The power to the wheels is through the transmission belts supplied by two 24VDC, flat amature, ***DC motors***. The motors and the power transmission to the wheels is constructed as one separate unit (Fig. 1).

The motor speed is control by the ***motor control board*** *(D101a)*. The motor control board is a programmable (from factory) permanent magnet speed controller. The speed is controlled by a four quadrant, full bridge power output which by pulse width modulation - at 15 kHz - provides the motors with forward speed, backward speed and braking. The acceleration up to full speed is linear for 3 sec. The push-too-fast feature activated with the mains switch in ON-position limits the maximum speed at which the MOBILETT can be pushed, thus protecting the MOBILETT from accelerating in e.g. steep inclines. Power save (25-min. key switch) turns off the board D101a when the motor is idling more than 25 minutes. After that period the ON/OFF switch has to be activated again.

The ***batteries*** are two 12V sealed lead-acid batteries connected in series and placed in a battery box. The battery output voltage +24VDC is supplied trough K103. The batteries are maintenance free with an estimated lifetime at normal use of more than 2 years.

The ***battery charger board*** *(D101b)*, powered by 100-240VAC, supplies the batteries with a constant voltage of 27.2 - 27.4 V. The battery charger is under operation when the mains cable is attached and the mains switch is in position 0. The input of the battery charger is fused by a 2.0 A fuse on the battery charger board. The output is fused by a 2.5 A fuse on the signal connection board.

The signal connection board (D101c) connects the signals between user controls, battery charger and motor control. The speed limiting pot RP1 is also located on the signal connection board. D101c also holds the fuses for the motor control input F20A and for the battery charger output F 2.5A.

A battery indicator is placed at the front cover showing the charging status. At charge limit 20% and lower the indicator light is flashing.

NOTICE	**All faults on the motor power unit other than blown fuses Fuse 20 A and Fuse 2.5 A shall result in replacement of the whole unit.**

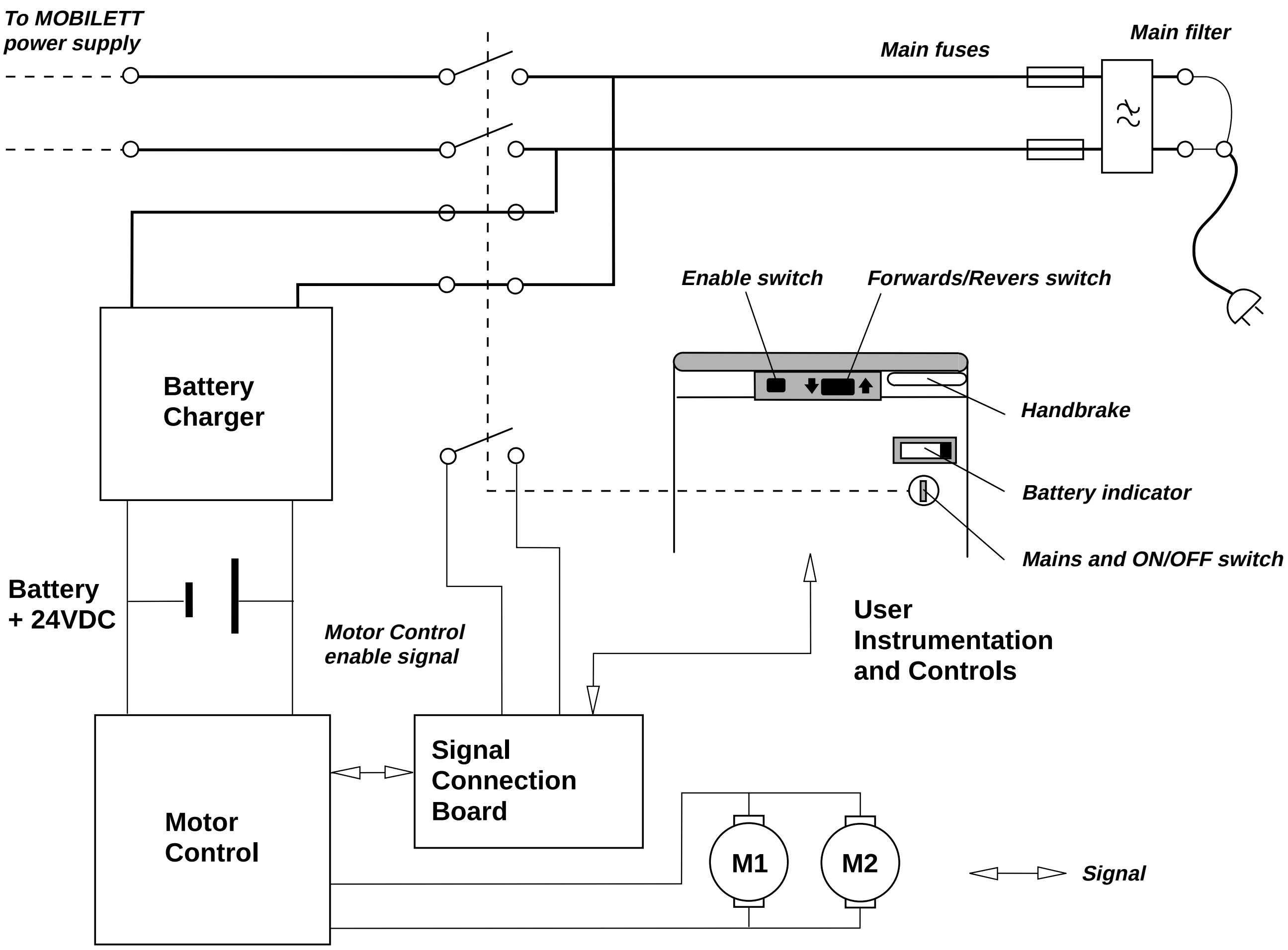

Fig. 2

Chap. 0		Chapter completely revised.
Chap. 12	Page 1	New information.
Chap. 14		Chapter completely revised. The information in the functional description for MOBILETT Plus HP and MOBILETT Plus/ Plus E/ Plus M is now equal.
Chap. 16	Page 2	New information.
	Page 3	New information.
Chap. 19	Page 1	New information
	Page 2	New information

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